



The Consultative Committee for Space Data Systems

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## Draft Recommendation for Space Data System Standards

# XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

**DRAFT RECOMMENDED STANDARD**

**CCSDS 505.0-R-1**

**RED BOOK**  
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## AUTHORITY

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**(WHEN THIS RECOMMENDED STANDARD IS FINALIZED, IT WILL CONTAIN THE FOLLOWING STATEMENT OF AUTHORITY:)**

This document has been approved for publication by the Management Council of the Consultative Committee for Space Data Systems (CCSDS) and represents the consensus technical agreement of the participating CCSDS Member Agencies. The procedure for review and authorization of CCSDS documents is detailed in the *Procedures Manual for the Consultative Committee for Space Data Systems*, and the record of Agency participation in the authorization of this document can be obtained from the CCSDS Secretariat at the address below.

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- o Whenever a member establishes a CCSDS-related **standard**, that member will provide other CCSDS members with the following information:
  - The **standard** itself.
  - The anticipated date of initial operational capability.
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No later than five years from its date of issuance, this **Recommended Standard** will be reviewed by the CCSDS to determine whether it should: (1) remain in effect without change; (2) be changed to reflect the impact of new technologies, new requirements, or new directions; or (3) be retired or canceled.

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## FOREWORD

**(WHEN THIS RECOMMENDED STANDARD IS FINALIZED, IT WILL CONTAIN THE FOLLOWING FOREWORD:)**

This document is a technical Recommended Standard for an XML Specification for Navigation Data Messages (Orbit Data Messages, Attitude Data Messages, Tracking Data Messages). It has been prepared by the Consultative Committee for Space Data Systems (CCSDS). The XML schema described in this Recommended Standard is the baseline concept for exchanging navigation data in XML format between Agencies of the CCSDS.

This Recommended Standard establishes a common framework and provides a common basis for the interchange of navigation data in XML format. It allows implementing organizations within each Agency to proceed coherently with the development of compatible derived standards for the flight and ground systems that are within their cognizance. Derived Agency standards may implement only a subset of the optional features allowed by the Recommended Standard and may incorporate features not addressed by this Recommended Standard.

Through the process of normal evolution, it is expected that expansion, deletion or modification to this document may occur. This Recommended Standard is therefore subject to CCSDS document management and change control procedures, as defined in the *Procedures Manual for the Consultative Committee for Space Data Systems*. Current versions of CCSDS documents are maintained at the CCSDS Web site:

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Questions relating to the contents or status of this document should be addressed to the CCSDS Secretariat at the address indicated on page i.

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## PREFACE

This document is a draft CCSDS Recommended Standard. Its ‘Red Book’ status indicates that the CCSDS believes the document to be technically mature and has released it for formal review by appropriate technical organizations. As such, its technical contents are not stable, and several iterations of it may occur in response to comments received during the review process.

Implementers are cautioned **not** to fabricate any final equipment in accordance with this document’s technical content.

## DOCUMENT CONTROL

<b>Document</b>	<b>Title</b>	<b>Date</b>	<b>Status</b>
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## 1 INTRODUCTION

### 1.1 PURPOSE

This draft Recommended Standard specifies a standard for use in exchanging spacecraft navigation data between space agencies. Such exchanges are used for distributing attitude, orbit, and tracking data between participating space agencies. This draft Recommended Standard has been developed via consensus of the Navigation Working Group of the CCSDS Mission Operations and Information Management Services (MOIMS) area. It describes an integrated XML schema that applies to all types of CCSDS approved Navigation Data Messages (NDM): Attitude Data Messages (ADM, see reference [1]), Orbit Data Messages (ODM, see reference [2]), and Tracking Data Messages (TDM, see reference [3]).

This document includes sets of requirements and criteria that the XML schema has been designed to meet. The rationale behind the design of the message is described in annex A and may help the application engineer construct a suitable message. For exchanges where these requirements do not capture the needs of the participating agencies another mechanism may be selected.

This XML schema is suited to inter-agency exchanges of any number of navigation data messages (ADM, ODM, and/or TDM).

### 1.2 SCOPE AND APPLICABILITY

This draft Recommended Standard is applicable only to the schema content and layout, and instantiations of the schema, but not to the transmission of any instantiation of the schema (note that the potential for compression/decompression of the message is an aspect of the transmission that is not part of this standard). The means of transmission of an XML-formatted NDM between agencies is beyond the scope of this document and should be specified via other arrangements, for example, an Interface Control Document (ICD). Transmission of an XML-formatted NDM could be based on the CCSDS Real-Time Radiometric Data Transfer Service Specification currently under development (White Book status as of October 2005), file based transfer protocol such as SFTP, streaming media, or services provided via the World Wide Web and XML-compatible web browsers. In general, it is a requirement that the transmission mechanism not place constraints on the technical data content of a navigation data message.

### 1.3 CONVENTIONS AND DEFINITIONS

The following conventions apply throughout this draft Recommended Standard:

- a) the words ‘shall’ and ‘must’ imply a binding and verifiable specification;
- b) the word ‘should’ implies an optional, but desirable, specification;
- c) the word ‘may’ implies an optional specification;

- d) the words ‘is’, ‘are’, and ‘will’ imply statements of fact.

## 1.4 STRUCTURE OF THIS DOCUMENT

Section 2 provides a very brief overview of the individual messages that constitute an NDM (i.e., ADM, ODM, TDM). It also provides a very brief overview of XML, and the justification for an integrated NDM/XML schema.

Section 3 provides an overview of the basic structure of the NDM/XML schema. This structure is external to the internal structure provided by the constituent messages.

Section 4 discusses information security considerations.

Annex A lists a set of requirements that were taken into consideration in the design of the NDM/XML Schema.

Annex B is a list of abbreviations and acronyms applicable to the NDM/XML.

Annexes C through I provide listings of the NDM/XML Master Schema, AEM Schema, APM Schema, OEM Schema, OPM Schema, TDM Schema, and NDM/XML Common Schema respectively.

Annex J consists of some example NDM/XML messages, with a description of where more test files can be located.<sup>1</sup>

Annex K contains a list of informative references.

## 1.5 REFERENCES

The following documents contain provisions which, through reference in this text, constitute provisions of this draft Recommended Standard. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this draft Recommended Standard are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS Recommended Standards.

- [1] *Attitude Data Messages*. Draft Recommendation for Space Data System Standards, CCSDS 504.0-R-1. Red Book. Issue 1. Washington, D.C.: CCSDS, November 2005.
- [2] *Orbit Data Messages*. Recommendation for Space Data System Standards, CCSDS 502.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2004.

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<sup>1</sup> This annex still needs to be populated with some simple NDM’s... the test file example that was formerly in the Annex is now on the CCSDS web page.

- [3] *Tracking Data Message.* Draft Recommendation for Space Data System Standards, CCSDS 503.0-R-1. Red Book. Issue 1. Washington, D.C.: CCSDS, November 2005.
- [4] *XML Schema Part 1: Structures.* 2nd ed. H. Thompson, et al., eds. W3C Recommendation 28. n.p.: W3C, 2004. <<http://www.w3.org/TR/2004/REC-xmlschema-1-20041028/>>
- [5] *XML Schema Part 2: Datatypes.* 2nd ed. P. Biron and A. Malhotra, eds. W3C Recommendation 28. n.p.: W3C, 2004. <<http://www.w3.org/TR/2004/REC-xmlschema-2-20041028/>>

NOTE – Informative references are provided in annex K.

## 2 OVERVIEW

### 2.1 GENERAL

This section will provide a brief overview of the set of Navigation Data Messages (NDM). There are three basic types of NDM (Attitude Data Messages, Orbit Data Messages, and the Tracking Data Message). The remainder of this document will convey the structure of the NDM in an integrated XML schema.

### 2.2 NAVIGATION DATA MESSAGES

#### 2.2.1 THE ATTITUDE DATA MESSAGE (ADM)

The ADM comprises two message types used to convey spacecraft attitude information: the Attitude Parameter Message (APM) and Attitude Ephemeris Message (AEM). The Attitude Parameter Message consists of an instantaneous attitude state and optional attitude maneuvers. The Attitude Ephemeris Message consists of a history/forecast of the attitude of the object that can be interpolated to obtain the attitude of the spacecraft at times other than those specified in the message. For a complete description of the APM and AEM, see reference [1].

#### 2.2.2 THE ORBIT DATA MESSAGE (ODM)

The ODM comprises two message types used to convey trajectory information: the Orbit Parameter Message (OPM) and Orbit Ephemeris Message (OEM). The OPM consists of a single state vector at a given time that represents the trajectory of the spacecraft; specifications of maneuvers are optional. The OEM represents a history/forecast of state vectors that can be interpolated to obtain the trajectory of the spacecraft at times other than those specified in the message. For a complete description of the OPM and OEM, see reference [2].

#### 2.2.3 THE TRACKING DATA MESSAGE (TDM)

The TDM comprises a single message type for use in exchanging spacecraft tracking data between space agencies. Such exchanges are used for distributing tracking data output from interagency cross supports in which spacecraft missions managed by one agency are tracked from a ground station managed by a second agency. Additionally, the ability to transfer tracking data between space agencies facilitates the allocation of tracking sessions to alternate antenna resources and increases the ability of space agencies to tolerate availability issues with their primary antennas. The TDM supports at least the following types: ground-based radio metric types: uplink frequencies, range, Doppler, antenna angles, and interferometric types; spacecraft-to-spacecraft Doppler and range; ancillary information needed to calculate the measurement residuals, such as meteorological data, media delays, and clock parameters. For a complete description of the TDM, see reference [3].

## 2.3 XML OVERVIEW

### 2.3.1 GENERAL

This section will briefly describe the Extensible Markup Language (XML), XML Schema and the justification for using it for Navigation Data Messages. For a complete description of XML Schema, see references [4] and [5]. In addition, for general information there are many popular books describing XML and how to use it.

### 2.3.2 XML OVERVIEW

**2.3.2.1** During the development of the ODM it was realized that the specified Keyword Value Notation (KVN) format was very limited and that it was not well suited to cover all possible needs of the Navigation Data Messages. XML, the ‘eXtensible Markup Language’, is a much better form of specifying ASCII-based data. This section will present a brief description of the broad features of XML.

**2.3.2.2** XML is similar to the HTML used for creating web pages, in that there are tags (begin tags and end tags) that specify how to organize the content. XML is different from HTML in that HTML tags are ‘fixed’, while XML provides an extensible framework that allows user-defined tag names that are structured according to the logic of the particular application domain in which the document content exists. Additionally, XML documents must be ‘well-formed’, whereas this restriction does not exist for HTML documents. Discussion of the details of ‘well-formedness’ are beyond the scope of this document, but it is essentially a set of rules that describe what constitutes a proper XML document. If the rules are not followed, the document cannot be rendered correctly.

**2.3.2.3** Some of the advantages of using XML instead of standard ASCII text files for this kind of application include:

- XML allows for the definition of the data message in a machine-readable format. The format is basically a template called a ‘schema’. This schema can then be referred to in the data file and it can be used to verify that the data is compliant with the schema. There are widely available programs to specify schemas, to assist with the processing of XML data, and to automatically verify that the data messages comply with the schema. Each participant in a data exchange can independently verify that the message is compliant. This simplifies the development and validation of the software used to write data in the proper format.
- XML defines standards for time formats and numerical values.
- XML allows for the nesting of data, so it is clear which metadata corresponds to which data.
- XML allows for the specification of default and alternative attributes, such as units.
- XML allows for compulsory and optional elements and attributes.

- XML allows for range checking and specification of lists of allowed values.
- XML allows for sharing elements between different specifications.

#### 2.3.2.4 A few disadvantages of using XML for this application are:

- Some values can be specified as either attributes or child elements, so there may be disagreement as to which method should be used.

NOTE – This flexibility can also be seen as an advantage, depending upon the application and the implementation.

- Tags are always duplicated, with the opening tag and the corresponding ending tag making files bigger (the byte count for tag information may exceed the byte count of the actual data associated with the tags). However, there are specific compressors for XML data that are much more efficient than those used for ASCII data (e.g., XMILL and XGRIND).
- There are not many Flight Dynamics specialists that are skilled in XML.

### 2.3.3 JUSTIFICATION FOR USING XML SCHEMA

There are several ways in which XML files can be processed: without validation, with validation via DTD, with validation via RELAX NG, with validation via Shematron, and with validation via XML schema. In the case of the CCSDS, the CCSDS Management Council (CMC) has indicated that XML schema shall be used for the XML validation (refer to CMC minutes of October 2002, Resolution MC-F02-09; at that time the CMC directed Panel 1J (precursor to Navigation Working Group) utilize PVL, or preferably XML schema, in the CCSDS 502.0-R-2 Orbit Data Messages).

### 2.3.4 JUSTIFICATION FOR INTEGRATED NDM/XML SCHEMA

The basic argument for creating an integrated NDM/XML schema proceeds from a position of symmetry and efficiency. There has been a movement towards the adoption of XML for space data systems data interchange between agencies. Since there are five separate NDM types, some of which have considerable overlap, it is more efficient to structure the XML format for the set of NDMs into an integrated whole. This will help to ensure as much consistency as possible between the message implementations, and will hopefully facilitate the coding of programs that will produce the messages that will be exchanged.

It is envisioned that the integrated NDM/XML schema will be hosted on a CCSDS web page accessible to all interested parties, and that agencies creating instantiations of the NDM/XML schema should map them to the CCSDS hosted NDM/XML schema. This will ensure that all instantiations of the NDM/XML schema can be validated in a consistent manner. This vision includes links to developer tools and test resources in addition to the official schema.

## DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

Currently, the NDM/XML schema is available at:

<http://public.ccsds.org/sites/cwe/moims-nav/Public/Schemas/>

In addition to the schemas, there are several test files and example NDM/XML instantiations.

### 3 BASIC STRUCTURE OF THE NDM/XML SCHEMA

#### 3.1 NDM BASIC STRUCTURE

**3.1.1** The basic element in the NDM/XML shall be a Navigation Data Message (NDM). The NDM shall consist of submessages called:

- Attitude Parameter Message (apm) (see reference [1]);
- Attitude Ephemeris Message (aem) (see reference [1]);
- Orbit Parameter Message (opm) (see reference [2]);
- Orbit Ephemeris Message (oem) (see reference [2]);
- Tracking Data Message (tdm) (see reference [3]).

**3.1.2** In general, an NDM should consist of at least one message (AEM, APM, OEM, OPM, or TDM). However, there are certain instances when it may be desirable to check connectivity via an NDM which is ‘empty’, i.e., contains only the outermost tag levels.

**3.1.3** Thus, the basic structure of an NDM shall be as shown in figure 3-1.

```
<ndm>
COMMENT generally, at least one AEM, APM, OEM, OPM, or TDM, unless “ping”).
COMMENT Note: the messages can occur in any quantity (including 0) or order.

<apm>
</apm>
<aem>
</aem>
<opm>
</opm>
<oem>
</oem>
<tdm>
</tdm>
</ndm>
```

**Figure 3-1: NDM/XML Basic Structure**

**3.1.4** Each message (APM, AEM, OPM, OEM, TDM) consists of a <header> and a <body>. Additionally, the body consists of one or more <segment> constructs, depending upon the message type. Each segment consists of a <metadata>/<data> pair. Note that the <body> and <segment> constructs are not explicitly specified in the constituent message documents (see references [1], [2], and [3]); however, they are logically implied, and are necessary in order to enforce the strict ordering of metadata and data sections. There are two

basic message substructures as discussed in the following two sections; one is used for the ‘parameter messages’ (APM, OPM), the other is used for the ‘ephemeris messages’ (AEM, OEM) and TDM.

### 3.2 SUBSTRUCTURE 1: **apm, opm**

In Substructure 1, the body consists of a single segment (in essence, the segment tag is not strictly necessary; however, it is present for structural symmetry with Substructure 2 in the ‘body’ of the message).

```
<header>
</header>
<body>
  <segment>
    <metadata>
    </metadata>
    <data>
    </data>
  </segment>
</body>
```

**Figure 3-2: NDM/XML Substructure for APM and OPM (apm, opm)**

### 3.3 SUBSTRUCTURE 2: **aem, oem, tdm**

In Substructure 2, the body consists of one or more segments. The alternation of associated metadata and data sections is the structural element that necessitates the notion of the segment.

```

<header>
</header>
<body>
  <segment>
    <metadata>
    </metadata>
    <data>
    </data>
  </segment>
  <segment>
    <metadata>
    </metadata>
    <data>
    </data>
  </segment>
  .
  .
  .
  <segment>
    <metadata>
    </metadata>
    <data>
    </data>
  </segment>
</body>

```

**Figure 3-3: NDM/XML Substructure for AEM, OEM, TDM (aem, oem, tdm)**

### 3.4 NDM/XML TAGS

Within the above structure and substructure, the individual tags specific to the various message types are defined. See references [1], [2], and [3] for the details regarding the contents of the specific tags. This document will describe the XML tags, which with rare exception are identical to the keywords in the reference documents.

As a general rule, an NDM/XML tag shall be all uppercase if it corresponds directly to a keyword in one of the reference documents. NDM/XML keywords that do not correspond directly to a keyword in one of the reference documents shall be in ‘lowerCamelCase’. CamelCase is a common name for the practice of writing compound words or phrases where the words are joined without spaces, and each word is capitalized within the compound. In the variant known as LowerCamelCase, the first word starts with a lowercase character, and each successive word has its first letter capitalized. If the tag consists of only a single word (e.g., ‘header’), the tag consists entirely of lowercase characters.

### **3.5 DISCUSSION OF ‘CHECKING’**

Note that there are some elements in the ADM, ODM, TDM that have structure for which checking is not done. Specifically, time systems, object names, reference frames, and center names could be defined by an enumerated list, and object IDs could be defined via a pattern that must be matched. However, it has been decided not to enforce these restrictions and allow a generic string to be used for the values associated with these concepts.

## 4 INFORMATION SECURITY

Navigation Data Messages (including the ODM, ADM and TDM) may require moderate security measures to protect the data from unauthorized access. Protection from unauthorized access is especially important if the mission utilizes open ground networks such as the Internet to provide ground station connectivity for the exchange of Navigation Data Messages. In order to provide requisite security, it is recommended that Navigation Data Messages be transferred between participants via Secure FTP (SFTP), real-time authentication such as that incorporated in the Real-Time Radio-Metric Data Transfer Service (RRMDT), or other secure mechanisms approved by the IT Security functionaries of exchange participants. As noted elsewhere in this document, this document does not deal specifically with the means of transferring Navigation Data Messages, focusing rather on content. Specific information security provisions that may apply between agencies involved in an exchange should be specified in an ICD.

**ANNEX A****RATIONALE FOR XML-FORMAT NAVIGATION DATA MESSAGES  
(INFORMATIVE)****A1 GENERAL**

This annex presents the rationale behind the design of the Navigation Data Message XML Specification. It may help the application engineer construct a suitable valid message. Corrections and/or additions to these requirements may occur during future updates.

A specification of requirements agreed to by all parties is essential to focus design and to ensure the product meets the needs of the Member Agencies. There are many ways of organizing requirements, but the categorization of requirements is not as important as the agreement to a sufficiently comprehensive set. In this annex the requirements are organized into three categories:

Primary Requirements - These are the most elementary and necessary requirements. They would exist no matter the context in which the CCSDS is operating: i.e., regardless of pre-existing conditions within the CCSDS or its Member Agencies.

Heritage Requirements - These are additional requirements that derive from pre-existing Member Agency requirements, conditions or needs. Ultimately these carry the same weight as the Primary Requirements. This draft Recommended Standard reflects heritage requirements pertaining to some of the technical participants' home institutions collected during the preparation of the draft Recommended Standard; it does not speculate on heritage requirements that could arise from other Member Agencies.

Desirable Characteristics - These are not requirements, but they are felt to be important or useful features of the draft Recommended Standard.

## A2 PRIMARY REQUIREMENTS ACCEPTED FOR XML-FORMAT NAVIGATION DATA MESSAGES

**Table A-1: Primary Requirements**

<u>ID</u>	<u>Requirement</u>	<u>Trace</u>
A-1-1	The NDM/XML data must be provided in digital form (computer file).	
A-1-2	The NDM/XML shall be represented by a valid XML format descriptor.	
A-1-3	The NDM/XML format descriptor shall be hosted on the CCSDS web site, and shared by all agencies exchanging instantiations of the format descriptor.	
A-1-4	The NDM/XML implementation shall allow for the representation of all the fields available in the Attitude Data Message (ADM) (reference [1]).	
A-1-5	The NDM/XML implementation shall allow for the representation of all the fields available in the Orbit Data Message (ODM) (reference [2]).	
A-1-6	The NDM/XML implementation shall allow for the representation of all the fields available in the Tracking Data Message (TDM) (reference [3]).	
A-1-7	Files must be readily portable between and useable within ‘all’ computational environments in use by Member Agencies choosing to exchange NDMs via XML.	
A-1-8	Files must have means of being uniquely identified and clearly annotated. The file name alone is considered insufficient for this purpose.	
A-1-9	File name syntax and length must not violate computer constraints for those computing environments in use by Member Agencies.	
A-1-10	The NDM/XML shall use XML elements where there is substructure associated with information, e.g., maneuver parameters.	
A-1-11	The NDM/XML shall use XML elements where there is data type checking associated with information, e.g., maneuver parameters.	

**Table A-2: Heritage Requirements**

<u>ID</u>	<u>Requirement</u>	<u>Trace</u>
A-2-1	The standard shall be, or must include, an ASCII format.	
A-2-2	The standard shall not require software supplied by other agencies to process valid instantiations of the NDM/XML schema.	

**Table A-3: Desirable Characteristics**

<u>ID</u>	<u>Requirement</u>	<u>Trace</u>
A-3-1	The standard should be extensible with no disruption to existing users/uses.	
A-3-2	Keywords, values, and terminology in the NDM/XML should be the same as those in the ODM, ADM, and TDM, insofar as it is possible.	
A-3-3	Structures in the NDM/XML should be re-used across the different message types where practical.	
A-3-4	The NDM/XML should minimize the use of tags that do not correspond to keywords in the ADM, ODM, or TDM.	
A-3-5	Units may be specified in the NDM/XML instantiations. The standard should provide for clear specification of units of measure.	
A-3-6	The NDM/XML may use XML attributes where there is no substructure associated with information (e.g., units specifications).	

**ANNEX B****ABBREVIATIONS AND ACRONYMS****(INFORMATIVE)**

ADM	Attitude Data Message
AEM	Attitude Ephemeris Message
aem	Attitude Ephemeris Message tag
APM	Attitude Parameter Message
apm	Attitude Parameter Message tag
ASCII	American Standard Code for Information Interchange
CCSDS	Consultative Committee on Space Data Systems
DTD	Document Type Definition
ICD	Interface Control Document
ISO	International Standards Organization
KVN	Keyword = Value notation
MOIMS	Mission Operations and Information Management Services
NDM	Navigation Data Message
ndm	Navigation Data Message tag
ODM	Orbit Data Message
OEM	Orbit Ephemeris Message
oem	Orbit Ephemeris Message tag
OPM	Orbit Parameter Message
opm	Orbit Parameter Message tag
PVL	Parameter Value Language
TDM	Tracking Data Message
tdm	Tracking Data Message tag
XML	eXtensible Markup Language

**ANNEX C**

**NDM/XML MASTER SCHEMA**  
**(NORMATIVE)**

This annex lists the NDM/XML Master Schema, the top level module in the modular schema. This XML Schema in conjunction with the NDM/XML instances referred to in annex J will validate successfully when validation-checked at:

<http://tools.decisionsoft.com/schemaValidate.html>

At the time of this publication the suggested URL is active. Users may need to find a current validation tool in the future.

The modular NDM/XML Schema may be found on the CCSDS web page at:

<http://public.ccsds.org/sites/cwe/moims-nav/Public/Schemas/>

NOTE – The Navigation Working Group is in favor of having CCSDS provide a standard XML validator, and perhaps other standardized XML developer tools, at an applicable CCSDS web site.

```

<?xml version="1.0"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">

<!--***** NOTE: This is version 1.8 of the NDM/XML Schema (09/30/2005). -->
<!-- This component of the schema is the Master module. -->
<!--
<!-- Compatible document versions are:
<!--     NDM/XML-50x.0.W-1.8 White Book (09/2005) -->
<!--     ODM 502.0-B-1 Blue Book (09/2004) -->
<!--     ADM 504.0-W-2.4 White Book (09/2005) -->
<!--     TDM 503.0-W-1.18 White Book (09/2005) -->
<!--
<!-- ***** WHITE BOOK CHANGE LOG *****
<!-- 09/30/2005 (Action item from Fall Meetings)
<!-- 1. Major upgrade to develop modularized schema, per several
<!--     recommendations/suggestions.
<!--
<!-- 09/12-16/2005 (Fall Meetings)
<!-- 1. Added compatibility with TDM 1.18 White Book
<!--
<!-- 09/2005 (preparation for Fall Meetings)
<!-- 1. Added compatibility with TDM 1.16 and 1.17 White Book
<!--
<!-- 08/2005
<!-- 1. Added compatibility with ADM 2.4 White Book
<!--
<!-- 07/2005
<!-- 1. Added this change log, per suggestion.
<!-- 2. Added ndmVersion element at the schema level, per suggestion. -->
```

## DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```
<!-- 3. Added compatibility with TDM 1.15 White Book -->
<!--*****-->

<!--*****-->
<!-- Structural note... this schema is structured so that the structural-->
<!-- elements of an NDM are developed in separate modules, i.e., there -->
<!-- are separate schemas for the AEM, APM, OEM, OPM, and TDM, each of -->
<!-- which is maintained separately. This facilitates the process of -->
<!-- applying updates that correlate with the foundation documents. -->
<!-- The "common" schema includes data types that may be shared across -->
<!-- more than one message. -->
<!--*****-->

<!--*****-->
<!-- Includes for all schema modules: AEM, APM, OEM, OPM, TDM, Common -->
<!--*****-->

<xsd:include schemaLocation="http://public.ccsds.org/sites/cwe/moims-
nav/Public/Schemas/ndmxml-aem-1.8.xsd"/>
<xsd:include schemaLocation="http://public.ccsds.org/sites/cwe/moims-
nav/Public/Schemas/ndmxml-apm-1.8.xsd"/>
<xsd:include schemaLocation="http://public.ccsds.org/sites/cwe/moims-
nav/Public/Schemas/ndmxml-oem-1.8.xsd"/>
<xsd:include schemaLocation="http://public.ccsds.org/sites/cwe/moims-
nav/Public/Schemas/ndmxml-opm-1.8.xsd"/>
<xsd:include schemaLocation="http://public.ccsds.org/sites/cwe/moims-
nav/Public/Schemas/ndmxml-tdm-1.8.xsd"/>
<xsd:include schemaLocation="http://public.ccsds.org/sites/cwe/moims-
nav/Public/Schemas/ndmxml-common-1.8.xsd"/>

<!--*****-->
<!-- NOTE: "ndm" is the root element in a Navigation Data Message (NDM) -->
<!--*****-->

<xsd:element name="ndm" type="ndmType" />

<xsd:complexType name="ndmType">
<!-- NOTE: In general, a Navigation Data Message (NDM) should consist -->
<!-- of at least *one* AEM, APM, OEM, OPM, or TDM. Beyond that, a -->
<!-- single NDM may consist of any number of AEMs, APMs, OEMs, OPMs-->
<!-- or TDMs, in any combination and order. Note that the setting -->
<!-- 'minOccurs="0"' at this level means that an empty NDM can be sent -->
<!-- for testing connectivity, if so desired. -->
<xsd:sequence>
    <xsd:element name="ndmVersion" type="ndmVersionType"/>
    <xsd:element name="COMMENT" type="xsd:string"
        minOccurs="0" maxOccurs="unbounded"/>
    <xsd:choice minOccurs="0" maxOccurs="unbounded">
        <xsd:element ref="aem" />
        <xsd:element ref="apm" />
        <xsd:element ref="oem" />
        <xsd:element ref="opm" />
        <xsd:element ref="tdm" />
    </xsd:choice>
</xsd:sequence>
</xsd:complexType>

<!--*****-->
```

## DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```
<!-- NOTE: The ndmVersion indicates which version of the NDM/XML schema -->
<!-- applies to a given NDM (AEM, APM, OEM, OPM, TDM) -->
<!--*****-->

<xsd:complexType name="ndmVersionType">
    <xsd:attribute name="version" type="ndmVersionString" use="required"
        fixed="0.1.8"/>
</xsd:complexType>

<xsd:simpleType name="ndmVersionString">
    <xsd:restriction base="xsd:string">
<!-- <xsd:pattern value="\p{Nd}\.\p{Nd}(\.\p{Nd})?" /> -->
    </xsd:restriction>
</xsd:simpleType>

</xsd:schema>
```

**ANNEX D****AEM SCHEMA  
(NORMATIVE)**

```

<?xml version="1.0"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">

<!--*****NOTE: This is version 1.8 of the NDM/XML Schema (09/xx/2005).-->
<!-- This component of the schema is the "AEM" module, which contains -->
<!-- elements that are used exclusively in the Attitude Ephemeris -->
<!-- Message (AEM). -->
<!--
<!-- Compatible document versions are:
<!--     NDM/XML-50x.0.W-1.8 White Book (09/2005)
<!--     ADM 504.0-W-2.5 White Book (09/2005)
<!--
<!-- ***** WHITE BOOK CHANGE LOG *****
<!-- 09/30/2005 (Action item from Fall Meetings)
<!-- 1. New module, introduced as part of the upgrade to a
<!--     modularized schema.
<!-- 2. Added compatibility with ADM 2.5 White Book
<!--
<!-- 08/2005
<!-- 1. Added compatibility with ADM 2.4 White Book
<!--
<!--*****NOTE: "aem" is the root element in an Attitude Ephemeris Message -->
<!--*****NOTE: "aem" is the root element in an Attitude Ephemeris Message -->

<xsd:element name="aem" type="aemType"/>

<!--*****An AEM consists of a "header" and a "body". The header is a
<!-- construct that is shared by all NDMs, found in the "common" schema-->
<!--*****An AEM consists of a "header" and a "body". The header is a
<!-- construct that is shared by all NDMs, found in the "common" schema-->

<xsd:complexType name="aemType">
  <xsd:sequence>
    <xsd:element name="header" type="ndmHeader"/>
    <xsd:element name="body" type="aemBody"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****The AEM "body" consists of 1 or more "segments", described below. -->
<!--*****The AEM "body" consists of 1 or more "segments", described below. -->

<xsd:complexType name="aemBody">
  <xsd:sequence>
    <xsd:element name="segment" type="aemSegment"
      minOccurs="1" maxOccurs="unbounded"/>
  </xsd:sequence>
</xsd:complexType>

```

## DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```
</xsd:complexType>

<!--*****>
<!-- The AEM "segment" consists of a "metadata" section and a "data"      -->
<!-- section. Note that the segment construct is implied, but not      -->
<!-- explicitly stated, in the structure of each AEM as described in the-->
<!-- ADM. Explicit statement of the segment construct is required in      -->
<!-- order to enforce the ordering and correspondence of metadata      -->
<!-- sections and data sections that is described in the ADM.          -->
<!--*****>

<xsd:complexType name="aemSegment">
  <xsd:sequence>
    <xsd:element name="metadata" type="aemMetadata"/>
    <xsd:element name="data" type="aemData"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****>
<!-- AEM Metadata Section                                         -->
<!--*****>

<xsd:complexType name="aemMetadata">
  <xsd:sequence>
    <xsd:element name="COMMENT" type="xsd:string"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="OBJECT_NAME" type="xsd:string"/>
    <xsd:element name="OBJECT_ID" type="xsd:string"/>
    <xsd:element name="CENTER_NAME" type="xsd:string"/>
    <xsd:element name="REF_FRAME" type="xsd:string"/>
    <xsd:element name="TIME_SYSTEM" type="xsd:string"/>
    <xsd:element name="START_TIME" type="epochType"/>
    <xsd:element name="USEABLE_START_TIME" type="epochType"
minOccurs="0"/>
    <xsd:element name="USEABLE_STOP_TIME" type="epochType"
minOccurs="0"/>
    <xsd:element name="STOP_TIME" type="epochType"/>
    <xsd:element name="ATTITUDE_TYPE" type="attitudeTypeType"/>
    <xsd:element name="QUATERNION_TYPE" type="quaternionTypeType"
      minOccurs="0"/>
    <xsd:element name="EULER_ROT_SEQ" type="rotseqType" minOccurs="0"/>
    <xsd:element name="INTERPOLATION_METHOD" type="xsd:string"
      minOccurs="0"/>
    <xsd:element name="INTERPOLATION_DEGREE" type="xsd:positiveInteger"
      minOccurs="0"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****>
<!-- AEM Data Section                                         -->
<!--*****>

<xsd:complexType name="aemData">
  <xsd:sequence>
    <xsd:element name="COMMENT" type="xsd:string"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="attitudeVector" type="attitudeVectorType"
      minOccurs="1" maxOccurs="unbounded"/>
  </xsd:sequence>
```

```

</xsd:complexType>

<!--*****>
<!-- "Attitude Vector Types" used in the AEM -->
<!--*****>

<xsd:complexType name="attitudeVectorType">
  <xsd:choice>
    <xsd:element name="quaternion" type="quaternionType"/>
    <xsd:element name="quaternionDerivative"
type="quaternionDerivativeType"/>
    <xsd:element name="quaternionEulerRate"
type="quaternionEulerRateType"/>
    <xsd:element name="eulerAngle" type="eulerAngleType"/>
    <xsd:element name="eulerAngleRate" type="eulerAngleRateType"/>
    <xsd:element name="spin" type="spinType"/>
    <xsd:element name="spinNutation" type="spinNutationType"/>
  </xsd:choice>
</xsd:complexType>

<xsd:complexType name="quaternionType">
<!-- type 1 AEM data -->
  <xsd:sequence>
    <xsd:element name="EPOCH" type="epochType"/>
    <xsd:choice>
      <xsd:sequence>
        <xsd:element name="QC" type="quaternionComponentType"/>
        <xsd:element name="Q1" type="quaternionComponentType"/>
        <xsd:element name="Q2" type="quaternionComponentType"/>
        <xsd:element name="Q3" type="quaternionComponentType"/>
      </xsd:sequence>
      <xsd:sequence>
        <xsd:element name="Q1" type="quaternionComponentType"/>
        <xsd:element name="Q2" type="quaternionComponentType"/>
        <xsd:element name="Q3" type="quaternionComponentType"/>
        <xsd:element name="QC" type="quaternionComponentType"/>
      </xsd:sequence>
    </xsd:choice>
  </xsd:sequence>
</xsd:complexType>

<xsd:complexType name="quaternionDerivativeType">
<!-- type 2 AEM data -->
  <xsd:sequence>
    <xsd:element name="EPOCH" type="epochType"/>
    <xsd:choice>
      <xsd:sequence>
        <xsd:element name="QC" type="quaternionComponentType"/>
        <xsd:element name="Q1" type="quaternionComponentType"/>
        <xsd:element name="Q2" type="quaternionComponentType"/>
        <xsd:element name="Q3" type="quaternionComponentType"/>
        <xsd:element name="QC_DOT" type="quaternionRateType"/>
        <xsd:element name="Q1_DOT" type="quaternionRateType"/>
        <xsd:element name="Q2_DOT" type="quaternionRateType"/>
        <xsd:element name="Q3_DOT" type="quaternionRateType"/>
      </xsd:sequence>
      <xsd:sequence>
        <xsd:element name="Q1" type="quaternionComponentType"/>
        <xsd:element name="Q2" type="quaternionComponentType"/>
        <xsd:element name="Q3" type="quaternionComponentType"/>
      </xsd:sequence>
    </xsd:choice>
  </xsd:sequence>
</xsd:complexType>

```

## DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```
<xsd:element name="QC" type="quaternionComponentType"/>
<xsd:element name="Q1_DOT" type="quaternionRateType"/>
<xsd:element name="Q2_DOT" type="quaternionRateType"/>
<xsd:element name="Q3_DOT" type="quaternionRateType"/>
<xsd:element name="QC_DOT" type="quaternionRateType"/>
</xsd:sequence>
</xsd:choice>
</xsd:sequence>
</xsd:complexType>

<xsd:complexType name="quaternionEulerRateType">
<!-- type 3 AEM data -->
<xsd:sequence>
<xsd:element name="EPOCH" type="epochType"/>
<xsd:choice>
<xsd:sequence>
<xsd:element name="QC" type="quaternionComponentType"/>
<xsd:element name="Q1" type="quaternionComponentType"/>
<xsd:element name="Q2" type="quaternionComponentType"/>
<xsd:element name="Q3" type="quaternionComponentType"/>
</xsd:sequence>
<xsd:sequence>
<xsd:element name="Q1" type="quaternionComponentType"/>
<xsd:element name="Q2" type="quaternionComponentType"/>
<xsd:element name="Q3" type="quaternionComponentType"/>
<xsd:element name="QC" type="quaternionComponentType"/>
</xsd:sequence>
</xsd:choice>
<xsd:element name="ROLL_RATE" type="angleRateType"/>
<xsd:element name="PITCH_RATE" type="angleRateType"/>
<xsd:element name="YAW_RATE" type="angleRateType"/>
</xsd:sequence>
</xsd:complexType>

<xsd:complexType name="eulerAngleType">
<!-- type 4 AEM data -->
<xsd:sequence>
<xsd:element name="EPOCH" type="epochType"/>
<xsd:element name="ROLL" type="angleType"/>
<xsd:element name="PITCH" type="angleType"/>
<xsd:element name="YAW" type="angleType"/>
</xsd:sequence>
</xsd:complexType>

<xsd:complexType name="eulerAngleRateType">
<!-- type 5 AEM data -->
<xsd:sequence>
<xsd:element name="EPOCH" type="epochType"/>
<xsd:element name="ROLL" type="angleType"/>
<xsd:element name="PITCH" type="angleType"/>
<xsd:element name="YAW" type="angleType"/>
<xsd:element name="ROLL_RATE" type="angleRateType"/>
<xsd:element name="PITCH_RATE" type="angleRateType"/>
<xsd:element name="YAW_RATE" type="angleRateType"/>
</xsd:sequence>
</xsd:complexType>

<xsd:complexType name="spinType">
<!-- type 3 AEM data -->
<xsd:sequence>
```

```

<xsd:element name="EPOCH" type="epochType"/>
<xsd:element name="SPIN_ALPHA" type="angleType"/>
<xsd:element name="SPIN_DELTA" type="angleType"/>
<xsd:element name="SPIN_ANGLE" type="angleType"/>
<xsd:element name="SPIN_ANGLE_VEL" type="angleRateType"/>
</xsd:sequence>
</xsd:complexType>

<xsd:complexType name="spinNutationType">
<!-- type 7 AEM data -->
<xsd:sequence>
    <xsd:element name="EPOCH" type="epochType"/>
    <xsd:element name="SPIN_ALPHA" type="angleType"/>
    <xsd:element name="SPIN_DELTA" type="angleType"/>
    <xsd:element name="SPIN_ANGLE" type="angleType"/>
    <xsd:element name="SPIN_ANGLE_VEL" type="angleRateType"/>
    <xsd:element name="NUTATION" type="angleType"/>
    <xsd:element name="NUTATION_PER" type="durationType"/>
</xsd:sequence>
</xsd:complexType>

<!--***** Simple Types and Complex Types Unique to the AEM -->
<!--***** Simple Types and Complex Types Unique to the AEM -->
<!--***** Simple Types and Complex Types Unique to the AEM -->

<xsd:simpleType name="attitudeTypeType">
    <xsd:restriction base="xsd:string">
        <xsd:enumeration value="quaternion"/>
        <xsd:enumeration value="QUATERNION"/>
        <xsd:enumeration value="quaternion/derivative"/>
        <xsd:enumeration value="QUATERNION/DERIVATIVE"/>
        <xsd:enumeration value="quaternion/rate"/>
        <xsd:enumeration value="QUATERNION/RATE"/>
        <xsd:enumeration value="euler_angle"/>
        <xsd:enumeration value="EULER_ANGLE"/>
        <xsd:enumeration value="euler_angle/rate"/>
        <xsd:enumeration value="EULER_ANGLE/RATE"/>
        <xsd:enumeration value="spin"/>
        <xsd:enumeration value="SPIN"/>
        <xsd:enumeration value="spin/nutation"/>
        <xsd:enumeration value="SPIN/NUTATION"/>
    </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="quaternionTypeType">
    <xsd:restriction base="xsd:string">
        <xsd:enumeration value="first"/>
        <xsd:enumeration value="FIRST"/>
        <xsd:enumeration value="last"/>
        <xsd:enumeration value="LAST"/>
    </xsd:restriction>
</xsd:simpleType>

</xsd:schema>

```

**ANNEX E****APM SCHEMA  
(NORMATIVE)**

```

<?xml version="1.0"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">

<!--*****NOTE: This is version 1.8 of the NDM/XML Schema (09/xx/2005).-->
<!-- This component of the schema is the "APM" module, which contains -->
<!-- elements that are used exclusively in the Attitude Parameter -->
<!-- Message (APM). -->
<!--
<!-- Compatible document versions are:
<!--     NDM/XML-50x.0.W-1.8 White Book (09/2005)
<!--     ADM 504.0-W-2.5 White Book (09/2005)
<!--
<!-- ***** WHITE BOOK CHANGE LOG *****
<!-- 09/30/2005 (Action item from Fall Meetings)
<!-- 1. New module, introduced as part of the upgrade to a
<!--     modularized schema.
<!-- 2. Added compatibility with ADM 2.5 White Book
<!--
<!-- 08/2005
<!-- 1. Added compatibility with ADM 2.4 White Book
<!--
<!--*****NOTE: "apm" is the root element in an Attitude Parameter Message -->
<!--*****NOTE: "body" consists of a single "segment", described below. -->

<xsd:element name="apm" type="apmType"/>

<!-- An APM consists of a "header" and a "body". The header is a
<!-- construct that is shared by all NDMs, found in the "common" schema-->
<!--*****NOTE: "body" consists of a single "segment", described below. -->
<xsd:complexType name="apmType">
    <xsd:sequence>
        <xsd:element name="header" type="ndmHeader"/>
        <xsd:element name="body" type="apmBody"/>
    </xsd:sequence>
</xsd:complexType>

<!-- The APM "body" consists of a single "segment", described below. -->
<!--*****NOTE: "body" consists of a single "segment", described below. -->
<xsd:complexType name="apmBody">
    <xsd:sequence>
        <xsd:element name="segment" type="apmSegment"
            minOccurs="1" maxOccurs="1"/>
    </xsd:sequence>
</xsd:complexType>

```

# DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```

<!--*****-->
<!-- The APM "segment" consists of a "metadata" section and a "data"      -->
<!-- section. Structurally it is not strictly necessary, however, for      -->
<!-- symmetry with the AEM it is included in the APM structure.          -->
<!--*****-->
<xsd:complexType name="apmSegment">
  <xsd:sequence>
    <xsd:element name="metadata" type="apmMetadata"/>
    <xsd:element name="data" type="apmData"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- APM Metadata Section                                         -->
<!--*****-->
<xsd:complexType name="apmMetadata">
  <xsd:sequence>
    <xsd:element name="COMMENT" type="xsd:string"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="OBJECT_NAME" type="xsd:string"/>
    <xsd:element name="OBJECT_ID" type="xsd:string"/>
    <xsd:element name="CENTER_NAME" type="xsd:string"/>
    <xsd:element name="TIME_SYSTEM" type="xsd:string"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- APM Data Section                                         -->
<!--*****-->
<xsd:complexType name="apmData">
  <xsd:sequence>
    <xsd:element name="COMMENT" type="xsd:string"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="stateVector" type="attStateVectorType"/>
    <xsd:element name="eulerElementsThree" type="eulerElementsThreeType"
      minOccurs="0"/>
    <xsd:element name="eulerElementsSpin" type="eulerElementsSpinType"
      minOccurs="0"/>
    <xsd:element name="spacecraftParameters"
      type="attSpacecraftParametersType" minOccurs="0"/>
    <xsd:element name="maneuverParameters"
      type="attManeuverParametersType" minOccurs="0"
      maxOccurs="unbounded"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- "Logical Blocks" used in the APM                         -->
<!--*****-->
<xsd:complexType name="attStateVectorType">
  <xsd:sequence>
    <xsd:element name="COMMENT" type="xsd:string"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="EPOCH" type="epochType"/>
    <xsd:element name="Q_FRAME" type="xsd:string"/>
    <xsd:element name="Q1" type="quaternionComponentType"/>
    <xsd:element name="Q2" type="quaternionComponentType"/>
    <xsd:element name="Q3" type="quaternionComponentType"/>
    <xsd:element name="QC" type="quaternionComponentType"/>
    <xsd:element name="Q1_DOT" type="xsd:double" minOccurs="0"/>

```

# DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```

<xsd:element name="Q2_DOT" type="xsd:double" minOccurs="0"/>
<xsd:element name="Q3_DOT" type="xsd:double" minOccurs="0"/>
<xsd:element name="QC_DOT" type="xsd:double" minOccurs="0"/>
</xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- NOTE: For some spacecraft, the "eulerElementsThreeType" and      -->
<!-- "eulerElementsSpinType" described in the next 2 sections may      -->
<!-- appear in the same APM, according to the AAC design of the      -->
<!-- spacecraft.                                              -->
<!--*****-->
<xsd:complexType name="eulerElementsThreeType">
    <xsd:sequence>
        <xsd:element name="COMMENT" type="xsd:string"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="EULER_FRAME" type="xsd:string"/>
        <xsd:element name="EULER_ROT_SEQ" type="rotseqType"/>
        <xsd:element name="ROLL" type="angleType"/>
        <xsd:element name="PITCH" type="angleType"/>
        <xsd:element name="YAW" type="angleType"/>
        <xsd:element name="ROLL_RATE" type="angleRateType"/>
        <xsd:element name="PITCH_RATE" type="angleRateType"/>
        <xsd:element name="YAW_RATE" type="angleRateType"/>
    </xsd:sequence>
</xsd:complexType>

<xsd:complexType name="eulerElementsSpinType">
    <xsd:sequence>
        <xsd:element name="COMMENT" type="xsd:string"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="SPIN_FRAME" type="xsd:string"/>
        <xsd:element name="SPIN_ALPHA" type="angleType"/>
        <xsd:element name="SPIN_DELTA" type="angleType"/>
        <xsd:element name="SPIN_ANGLE" type="angleType"/>
        <xsd:element name="SPIN_ANGLE_VEL" type="angleRateType"/>
        <xsd:element name="NUTATION" type="angleType"/>
        <xsd:element name="NUTATION_PER" type="positiveDouble"/>
    </xsd:sequence>
</xsd:complexType>

<xsd:complexType name="attSpacecraftParametersType">
    <xsd:sequence>
        <xsd:element name="COMMENT" type="xsd:string"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="IX" type="momentType"/>
        <xsd:element name="IY" type="momentType"/>
        <xsd:element name="IZ" type="momentType"/>
        <xsd:element name="IXY" type="productMomentType"/>
        <xsd:element name="IXZ" type="productMomentType"/>
        <xsd:element name="IYZ" type="productMomentType"/>
    </xsd:sequence>
</xsd:complexType>

<xsd:complexType name="attManeuverParametersType">
    <xsd:sequence>
        <xsd:element name="COMMENT" type="xsd:string"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="MAN_EPOCH_START" type="epochType"/>
        <xsd:element name="MAN_DURATION" type="nonNegativeDouble"/>
    </xsd:sequence>
</xsd:complexType>

```

## DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```
<xsd:element name="MAN_REF_FRAME" type="xsd:string"/>
<xsd:element name="MAN_TOR_1" type="torqueType"/>
<xsd:element name="MAN_TOR_2" type="torqueType"/>
<xsd:element name="MAN_TOR_3" type="torqueType"/>
</xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- Simple Types and Complex Types Unique to the APM.          -->
<!--*****-->

<xsd:complexType name="momentType">
  <xsd:simpleContent>
    <xsd:extension base="nonNegativeDouble">
      <xsd:attribute name="units" type="momentUnits" use="optional"/>
    </xsd:extension>
  </xsd:simpleContent>
</xsd:complexType>

<xsd:complexType name="productMomentType">
  <xsd:simpleContent>
    <xsd:extension base="xsd:double">
      <xsd:attribute name="units" type="momentUnits" use="optional"/>
    </xsd:extension>
  </xsd:simpleContent>
</xsd:complexType>

<xsd:simpleType name="momentUnits">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="kg*m**2"/>
    <xsd:enumeration value="KG*M**2"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:complexType name="torqueType">
  <xsd:simpleContent>
    <xsd:extension base="xsd:double">
      <xsd:attribute name="units" type="torqueUnits" use="optional"/>
    </xsd:extension>
  </xsd:simpleContent>
</xsd:complexType>

<xsd:simpleType name="torqueUnits">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="n*m"/>
    <xsd:enumeration value="N*m"/>
    <xsd:enumeration value="N*M"/>
  </xsd:restriction>
</xsd:simpleType>

</xsd:schema>
```

**ANNEX F****OEM SCHEMA  
(NORMATIVE)**

```

<?xml version="1.0"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">

<!--*****NOTE: This is version 1.8 of the NDM/XML Schema (09/30/2005).-->
<!-- This component of the schema is the "OEM" module, which contains-->
<!-- elements that are used exclusively in the Orbit Ephemeris-->
<!-- Message (OEM).-->
<!-->
<!-- Compatible document versions are:-->
<!--    NDM/XML-50x.0.W-1.8 White Book (09/2005)-->
<!--    ODM 502.0-B-1 Blue Book (09/2004)-->
<!-->
<!-- ***** WHITE BOOK CHANGE LOG *****-->
<!-- 09/30/2005 (Action item from Fall Meetings)-->
<!-- 1. New module, introduced as part of the upgrade to a-->
<!--     modularized schema.-->
<!--*****-->

<!--*****NOTE: "oem" is the root element in a Orbit Ephemeris Message (OEM)-->
<!--*****-->

<xsd:element name="oem" type="oemType"/>

<!--*****-->
<!-- An OEM consists of a "header" and a "body". The header is a-->
<!-- construct that is shared by all NDMs, found in the "common" schema-->
<!--*****-->

<xsd:complexType name="oemType">
  <xsd:sequence>
    <xsd:element name="header" type="ndmHeader"/>
    <xsd:element name="body" type="oemBody"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- The OEM "body" consists of 1 or more "segments", described below.-->
<!--*****-->

<xsd:complexType name="oemBody">
  <xsd:sequence>
    <xsd:element name="segment" type="oemSegment"
      minOccurs="1" maxOccurs="unbounded"/>
  </xsd:sequence>
</xsd:complexType>

```

## DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```
<!--*****>
<!-- The OEM "segment" consists of a "metadata" section and a "data"      -->
<!-- section. Note that the segment construct is implied, but not          -->
<!-- explicitly stated, in the structure of each OEM as described in the-->
<!-- ODM. Explicit statement of the segment construct is required in      -->
<!-- order to enforce the ordering and correspondence of metadata        -->
<!-- sections and data sections that is described in the ODM.            -->
<!--*****>

<xsd:complexType name="oemSegment">
  <xsd:sequence>
    <xsd:element name="metadata" type="oemMetadata"/>
    <xsd:element name="data" type="oemData"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****>
<!-- OEM Metadata Section                                         -->
<!--*****>

<xsd:complexType name="oemMetadata">
  <xsd:sequence>
    <xsd:element name="COMMENT" type="xsd:string"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="OBJECT_NAME" type="xsd:string"/>
    <xsd:element name="OBJECT_ID" type="xsd:string"/>
    <xsd:element name="CENTER_NAME" type="xsd:string"/>
    <xsd:element name="REF_FRAME" type="xsd:string"/>
    <xsd:element name="TIME_SYSTEM" type="xsd:string"/>
    <xsd:element name="START_TIME" type="epochType"/>
    <xsd:element name="USEABLE_START_TIME" type="epochType"
minOccurs="0"/>
    <xsd:element name="USEABLE_STOP_TIME" type="epochType"
minOccurs="0"/>
    <xsd:element name="STOP_TIME" type="epochType"/>
    <xsd:element name="INTERPOLATION" type="xsd:string"
      minOccurs="0"/>
    <xsd:element name="INTERPOLATION_DEGREE" type="xsd:positiveInteger"
      minOccurs="0"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****>
<!-- OEM Data Section                                         -->
<!--*****>

<xsd:complexType name="oemData">
  <xsd:sequence>
    <xsd:element name="COMMENT" type="xsd:string"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="stateVector" type="stateVectorType"
      minOccurs="1" maxOccurs="unbounded"/>
  </xsd:sequence>
</xsd:complexType>

</xsd:schema>
```

**ANNEX G****OPM SCHEMA  
(NORMATIVE)**

```

<?xml version="1.0"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">

<!--*****NOTE: This is version 1.8 of the NDM/XML Schema (09/xx/2005).-->
<!-- This component of the schema is the "OPM" module, which contains-->
<!-- elements that are used exclusively in the Orbit Parameter-->
<!-- Message (OPM).-->
<!-->
<!-- Compatible document versions are:-->
<!--    NDM/XML-50x.0.W-1.8 White Book (09/2005)-->
<!--    ODM 502.0-B-1 Blue Book (09/2004)-->
<!-->
<!-->
<!-- ***** WHITE BOOK CHANGE LOG *****-->
<!-- 09/30/2005 (Action item from Fall Meetings)-->
<!-- 1. New module, introduced as part of the upgrade to a-->
<!--     modularized schema.-->
<!--*****-->

<!--*****NOTE: "opm" is the root element in a Orbit Parameter Message (OPM)-->
<!--*****-->

<xsd:element name="opm" type="opmType"/>

<!--*****-->
<!-- An OPM consists of a "header" and a "body". The header is a-->
<!-- construct that is shared by all NDMs, found in the "common" schema-->
<!--*****-->
<xsd:complexType name="opmType">
  <xsd:sequence>
    <xsd:element name="header" type="ndmHeader"/>
    <xsd:element name="body" type="opmBody"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- The OPM "body" consists of a single "segment", described below.-->
<!--*****-->
<xsd:complexType name="opmBody">
  <xsd:sequence>
    <xsd:element name="segment" type="opmSegment"
      minOccurs="1" maxOccurs="1"/>
  </xsd:sequence>
</xsd:complexType>

```

## DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```

<!--*****-->
<!-- The OPM "segment" consists of a "metadata" section and a "data"    -->
<!-- section. Structurally it is not strictly necessary, however, for    -->
<!-- symmetry with the OEM it is included in the OPM structure.        -->
<!--*****-->
<xsd:complexType name="opmSegment">
  <xsd:sequence>
    <xsd:element name="metadata" type="opmMetadata"/>
    <xsd:element name="data" type="opmData"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- OPM Metadata Section                                         -->
<!--*****-->
<xsd:complexType name="opmMetadata">
  <xsd:sequence>
    <xsd:element name="COMMENT" type="xsd:string"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="OBJECT_NAME" type="xsd:string"/>
    <xsd:element name="OBJECT_ID" type="xsd:string"/>
    <xsd:element name="CENTER_NAME" type="xsd:string"/>
    <xsd:element name="REF_FRAME" type="xsd:string"/>
    <xsd:element name="TIME_SYSTEM" type="xsd:string"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- OPM Data Section                                         -->
<!--*****-->
<xsd:complexType name="opmData">
  <xsd:sequence>
    <xsd:element name="COMMENT" type="xsd:string"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="stateVector" type="stateVectorType"/>
    <xsd:element name="keplerianElements" type="keplerianElementsType"
      minOccurs="0"/>
    <xsd:element name="spacecraftParameters"
      type="spacecraftParametersType"/>
    <xsd:element name="maneuverParameters"
      type="maneuverParametersType"
      minOccurs="0" maxOccurs="unbounded"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- "Logical Blocks" Unique to the OPM (stateVector is shared, so it    -->
<!-- is found in the "common" schema).                                     -->
<!--*****-->
<xsd:complexType name="keplerianElementsType">
  <xsd:sequence>
    <xsd:element name="COMMENT" type="xsd:string"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="SEMI_MAJOR_AXIS" type="distanceType"/>
    <xsd:element name="ECCENTRICITY" type="nonNegativeDouble"/>
    <xsd:element name="INCLINATION" type="inclinationType"/>
    <xsd:element name="RA_OF_ASC_NODE" type="angleType"/>
    <xsd:element name="ARG_OF_PERICENTER" type="angleType"/>

```

```

<xsd:choice>
    <xsd:element name="TRUE_ANOMALY" type="angleType"/>
    <xsd:element name="MEAN_ANOMALY" type="angleType"/>
</xsd:choice>
<xsd:element name="GM" type="gmType"/>
</xsd:sequence>
</xsd:complexType>

<xsd:complexType name="spacecraftParametersType">
    <xsd:sequence>
        <xsd:element name="COMMENT" type="xsd:string"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="MASS" type="massType"/>
        <xsd:element name="SOLAR_RAD_AREA" type="areaType"/>
        <xsd:element name="SOLAR_RAD_COEFF" type="nonNegativeDouble"/>
        <xsd:element name="DRAG_AREA" type="areaType"/>
        <xsd:element name="DRAG_COEFF" type="nonNegativeDouble"/>
    </xsd:sequence>
</xsd:complexType>

<xsd:complexType name="maneuverParametersType">
    <xsd:sequence>
        <xsd:element name="COMMENT" type="xsd:string"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="MAN_EPOCH_IGNITION" type="epochType"/>
        <xsd:element name="MAN_DURATION" type="durationType"/>
        <xsd:element name="MAN_DELTA_MASS" type="deltamassType"/>
        <xsd:element name="MAN_REF_FRAME" type="xsd:string"/>
        <xsd:element name="MAN_DV_1" type="speedType"/>
        <xsd:element name="MAN_DV_2" type="speedType"/>
        <xsd:element name="MAN_DV_3" type="speedType"/>
    </xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- Simple Types and Complex Types Unique to the OPM. -->
<!--*****-->

<xsd:complexType name="inclinationType">
    <xsd:simpleContent>
        <xsd:extension base="inclination">
            <xsd:attribute name="units" type="angleUnits" use="optional"/>
        </xsd:extension>
    </xsd:simpleContent>
</xsd:complexType>

<xsd:simpleType name="inclination">
    <xsd:restriction base="angleRange">
        <xsd:minInclusive value="0.0"/>
        <xsd:maxInclusive value="180.0"/>
    </xsd:restriction>
</xsd:simpleType>

<xsd:complexType name="gmType">
    <xsd:simpleContent>
        <xsd:extension base="positiveDouble">

```

## DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```
<xsd:attribute name="units" type="gmUnits" use="optional"/>
</xsd:extension>
</xsd:simpleContent>
</xsd:complexType>

<xsd:simpleType name="gmUnits">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="km**3/s**2"/>
    <xsd:enumeration value="KM**3/S**2"/>
  </xsd:restriction>
</xsd:simpleType>

</xsd:schema>
```

**ANNEX H****TDM SCHEMA  
(NORMATIVE)**

```

<?xml version="1.0"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">

<!--*****NOTE: This is version 1.8 of the NDM/XML Schema (09/xx/2005).-->
<!-- This component of the schema is the "TDM" module, which contains-->
<!-- elements that are used exclusively in the Tracking Data Message-->
<!-- (TDM).-->
<!--
<!-- Compatible document versions are:
<!--     NDM/XML-50x.0.W-1.9 White Book (10/2005)
<!--     TDM 503.0-W-1.18 White Book (09/2005)
<!--
<!-- ***** WHITE BOOK CHANGE LOG *****
<!-- 09/30/2005 (Action item from Fall Meetings)
<!-- 1. New module, introduced as part of the upgrade to a
<!--     modularized schema.
<!-- 2. Enhanced compatibility with TDM 1.18 White Book
<!--
<!-- 09/2005 (Fall Meetings)
<!-- 1. Added compatibility with TDM 1.18 White Book
<!--
<!-- 09/2005 (preparation for Fall Meetings)
<!-- 1. Added compatibility with TDM 1.16 and 1.17 White Book
<!--
<!-- 07/2005
<!-- 1. Added compatibility with TDM 1.15 White Book
<!--
<!--*****NOTE: "tdm" is the root element in a Tracking Data Message-->
<!--*****
```

<xsd:element name="tdm" type="tdmType"/>

```

<!--*****A TDM consists of a "header" and a "body". The header is a
<!-- construct that is shared by all NDMs, found in the "common" schema-->
<!--*****
```

<xsd:complexType name="tdmType">

<xsd:sequence>

<xsd:element name="header" type="ndmHeader"/>

<xsd:element name="body" type="tdmBody"/>

</xsd:sequence>

</xsd:complexType>

```

<!--*****The TDM "body" consists of 1 or more "segments", described below.-->
<!--*****
```

# DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```
<xsd:complexType name="tdmBody">
  <xsd:sequence>
    <xsd:element name="segment" type="tdmSegment"
      minOccurs="1" maxOccurs="unbounded"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- The TDM "segment" consists of a "metadata" section and a "data"      -->
<!-- section. Note that the segment construct is implied, but not      -->
<!-- explicitly stated, in the structure of each TDM as described in the-->
<!-- TDM. Explicit statement of the segment construct is required in      -->
<!-- order to enforce the ordering and correspondence of metadata      -->
<!-- sections and data sections that is described in the TDM.          -->
<!--*****-->

<xsd:complexType name="tdmSegment">
  <xsd:sequence>
    <xsd:element name="metadata" type="tdmMetadata"/>
    <xsd:element name="data" type="tdmData"/>
  </xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- TDM Metadata Section                                         -->
<!--*****-->

<xsd:complexType name="tdmMetadata">
  <xsd:sequence>
    <xsd:element name="COMMENT" type="xsd:string"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="TIME_SYSTEM" type="xsd:string"/>
    <xsd:element name="PARTICIPANT_1" type="xsd:string"/>
    <xsd:element name="PARTICIPANT_2" type="xsd:string"
      minOccurs="0"/>
    <xsd:element name="PARTICIPANT_3" type="xsd:string"
      minOccurs="0"/>
    <xsd:element name="PARTICIPANT_4" type="xsd:string"
      minOccurs="0"/>
    <xsd:element name="PARTICIPANT_5" type="xsd:string"
      minOccurs="0"/>
    <xsd:element name="MODE" type="modeType" />
    <xsd:element name="PATH" type="pathType" default="N/A"
      minOccurs="0" />
    <xsd:element name="DIFF_MODE" type="diffmodeType" default="N/A"
      minOccurs="0" />
    <xsd:element name="TIMETAG_REF" type="timetagType" default="RECEIVE"
      minOccurs="0" />
    <xsd:element name="INTEGRATION_INTERVAL" type="nonNegativeDouble"
      default="1.0" minOccurs="0"/>
    <xsd:element name="INTEGRATION_REF" type="integrationrefType"
      default="MIDDLE" minOccurs="0" />
    <xsd:element name="FREQ_OFFSET" type="xsd:double" default="0.0"
      minOccurs="0" />
    <xsd:element name="RANGE_MODE" type="rangemodeType"
      default="COHERENT"
      minOccurs="0" />
    <xsd:element name="RANGE_MODULUS" type="nonNegativeDouble"
```

```

        default="0.0" minOccurs="0" />
<xsd:element name="RANGE_UNITS" type="rangeunitsType" default="S"
    minOccurs="0" />
<xsd:element name="ANGLE_TYPE" type="angleTypeType" default="N/A"
    minOccurs="0" />
<xsd:element name="REFERENCE_FRAME" type="xsd:string" default="N/A"
    minOccurs="0" />
<xsd:element name="TRANSMIT_DELAY_1" type="nonNegativeDouble"
    default="0.0" minOccurs="0" />
<xsd:element name="TRANSMIT_DELAY_2" type="nonNegativeDouble"
    default="0.0" minOccurs="0" />
<xsd:element name="TRANSMIT_DELAY_3" type="nonNegativeDouble"
    default="0.0" minOccurs="0" />
<xsd:element name="TRANSMIT_DELAY_4" type="nonNegativeDouble"
    default="0.0" minOccurs="0" />
<xsd:element name="TRANSMIT_DELAY_5" type="nonNegativeDouble"
    default="0.0" minOccurs="0" />
<xsd:element name="RECEIVE_DELAY_1" type="nonNegativeDouble"
    default="0.0" minOccurs="0" />
<xsd:element name="RECEIVE_DELAY_2" type="nonNegativeDouble"
    default="0.0" minOccurs="0" />
<xsd:element name="RECEIVE_DELAY_3" type="nonNegativeDouble"
    default="0.0" minOccurs="0" />
<xsd:element name="RECEIVE_DELAY_4" type="nonNegativeDouble"
    default="0.0" minOccurs="0" />
<xsd:element name="RECEIVE_DELAY_5" type="nonNegativeDouble"
    default="0.0" minOccurs="0" />
<xsd:element name="START_TIME" type="epochType" />
<xsd:element name="STOP_TIME" type="epochType" />
<xsd:element name="DATA_QUALITY" type="dataQualityType"
    default="VALIDATED" minOccurs="0" />
<xsd:element name="CORRECTION_RNGCAL" type="xsd:double"
    minOccurs="0" />
<xsd:element name="CORRECTION_ANGLE_1" type="xsd:double"
    minOccurs="0" />
<xsd:element name="CORRECTION_ANGLE_2" type="xsd:double"
    minOccurs="0" />
<xsd:element name="CORRECTION_DOPPLER" type="xsd:double"
    minOccurs="0" />
<xsd:element name="CORRECTION_TROPO" type="xsd:double" minOccurs="0"
/>
<xsd:element name="CORRECTION_CP" type="xsd:double" minOccurs="0" />
</xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- TDM Data Section -->
<!--*****-->

<xsd:complexType name="tdmData">
    <xsd:sequence>
        <xsd:element name="COMMENT" type="xsd:string"
            minOccurs="0" maxOccurs="unbounded" />
        <xsd:element name="observation"
            type="trackingDataObservationType"
            minOccurs="1" maxOccurs="unbounded" />
    </xsd:sequence>
</xsd:complexType>
```

# DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```

<!--*****-->
<!-- Simple Types and Complex Types unique to the TDM -->
<!--*****-->

<!--*****-->
<!-- NOTE: The following structure of the TDM Data Section is based on -->
<!-- an "observation". Each observation contains a given epoch time, -->
<!-- and the observable as of the epoch time. This structure reduces the-->
<!-- pre-processing required to build a TDM from disparate input -->
<!-- sources. -->
<!--*****-->

<xsd:complexType name="trackingDataObservationType">
    <xsd:sequence>
        <xsd:element name="EPOCH" type="epochType"/>
        <xsd:choice>
            <xsd:element name="AGC" type="xsd:double" />
            <xsd:element name="ANGLE_1" type="angleType"/>
            <xsd:element name="ANGLE_2" type="angleType"/>
            <xsd:element name="AZIMUTH_RATE" type="xsd:double"/>
            <xsd:element name="CARRIER_SNR" type="xsd:double"/>
            <xsd:element name="CLOCK_BIAS" type="xsd:double" default="0.0"/>
            <xsd:element name="CLOCK_DRIFT" type="xsd:double" default="0.0"/>
            <xsd:element name="CPDELAY" type="xsd:double" />
            <xsd:element name="PRESSURE" type="xsd:double"/>
            <xsd:element name="RANGE_OBS" type="xsd:double"/>
            <xsd:element name="RANGE_RATE" type="xsd:double"/>
            <xsd:element name="RANGE_SNR" type="xsd:double"/>
            <xsd:element name="RECEIVE_FREQ" type="xsd:double"/>
            <xsd:element name="RECEIVE_FREQ_1" type="xsd:double"/>
            <xsd:element name="RECEIVE_FREQ_2" type="xsd:double"/>
            <xsd:element name="RECEIVE_FREQ_3" type="xsd:double"/>
            <xsd:element name="RECEIVE_FREQ_4" type="xsd:double"/>
            <xsd:element name="RECEIVE_FREQ_5" type="xsd:double"/>
            <xsd:element name="RHUMIDITY" type="percentType"/>
            <xsd:element name="TEMPERATURE" type="nonNegativeDouble"/>
            <xsd:element name="TRANSMIT_FREQ_1" type="positiveDouble"/>
            <xsd:element name="TRANSMIT_FREQ_2" type="positiveDouble"/>
            <xsd:element name="TRANSMIT_FREQ_3" type="positiveDouble"/>
            <xsd:element name="TRANSMIT_FREQ_4" type="positiveDouble"/>
            <xsd:element name="TRANSMIT_FREQ_5" type="positiveDouble"/>
            <xsd:element name="TRANSMIT_FREQ_RATE_1" type="xsd:double"/>
            <xsd:element name="TRANSMIT_FREQ_RATE_2" type="xsd:double"/>
            <xsd:element name="TRANSMIT_FREQ_RATE_3" type="xsd:double"/>
            <xsd:element name="TRANSMIT_FREQ_RATE_4" type="xsd:double"/>
            <xsd:element name="TRANSMIT_FREQ_RATE_5" type="xsd:double"/>
            <xsd:element name="TROPO_DRY" type="nonNegativeDouble"/>
            <xsd:element name="TROPO_WET" type="nonNegativeDouble"/>
        </xsd:choice>
    </xsd:sequence>
</xsd:complexType>

<xsd:simpleType name="timeRef">
    <xsd:restriction base="xsd:string">
        <xsd:enumeration value="start"/>
        <xsd:enumeration value="Start"/>
        <xsd:enumeration value="START"/>
        <xsd:enumeration value="end" />
        <xsd:enumeration value="End" />
        <xsd:enumeration value="END" />
    </xsd:restriction>

```

```

</xsd:simpleType>

<xsd:simpleType name="dataQualityType">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="raw"/>
    <xsd:enumeration value="RAW"/>
    <xsd:enumeration value="validated" />
    <xsd:enumeration value="VALIDATED" />
    <xsd:enumeration value="degraded" />
    <xsd:enumeration value="DEGRADED" />
  </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="modeType">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="SEQUENTIAL"/>
    <xsd:enumeration value="sequential"/>
    <xsd:enumeration value="SINGLE-DIFF" />
    <xsd:enumeration value="single-diff" />
    <xsd:enumeration value="DOUBLE-DIFF" />
    <xsd:enumeration value="double-diff" />
    <xsd:enumeration value="N/A"/>
    <xsd:enumeration value="n/a"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="pathType">
<!-- need better pattern here -->
<!-- once group decides desired pattern in the path -->
  <xsd:restriction base="xsd:string">
<!--   <xsd:pattern value="\d{2,9}"/>           -->
      <xsd:pattern value="\d{1},\d{1}(,\d{1})*|N\A"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="timetagType">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="TRANSMIT"/>
    <xsd:enumeration value="transmit"/>
    <xsd:enumeration value="RECEIVE"/>
    <xsd:enumeration value="receive"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="diffmodeType">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="delay"/>
    <xsd:enumeration value="DELAY"/>
    <xsd:enumeration value="range"/>
    <xsd:enumeration value="RANGE"/>
    <xsd:enumeration value="N/A" />
    <xsd:enumeration value="n/a" />
  </xsd:restriction>
</xsd:simpleType>

```

## DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```
<xsd:simpleType name="integrationrefType">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="START"/>
    <xsd:enumeration value="start"/>
    <xsd:enumeration value="MIDDLE"/>
    <xsd:enumeration value="middle"/>
    <xsd:enumeration value="END"/>
    <xsd:enumeration value="end"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="rangeunitsType">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="ru"/>
    <xsd:enumeration value="RU"/>
    <xsd:enumeration value="s"/>
    <xsd:enumeration value="S"/>
    <xsd:enumeration value="km"/>
    <xsd:enumeration value="KM"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="rangemodeType">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="coherent"/>
    <xsd:enumeration value="COHERENT"/>
    <xsd:enumeration value="constant"/>
    <xsd:enumeration value="CONSTANT"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="angleTypeType">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="AZEL"/>
    <xsd:enumeration value="azel"/>
    <xsd:enumeration value="RADEC"/>
    <xsd:enumeration value="radec"/>
    <xsd:enumeration value="XEYN"/>
    <xsd:enumeration value="xeyn"/>
    <xsd:enumeration value="XSYE"/>
    <xsd:enumeration value="xsye"/>
    <xsd:enumeration value="N/A"/>
    <xsd:enumeration value="n/a"/>
  </xsd:restriction>
</xsd:simpleType>

</xsd:schema>
```

**ANNEX I****NDM/XML COMMON SCHEMA  
(NORMATIVE)**

```

<?xml version="1.0"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">

<!--*****-->
<!-- NOTE: This is version 1.8 of the NDM/XML Schema (09/xx/2005). -->
<!-- This component of the schema is the "common" module, which contains-->
<!-- only simple types and complex types used by the constituent schemas-->
<!-- that make up Navigation Data Messages (AEM, APM, OEM, OPM, TDM). -->
<!-- -->
<!-- Compatible document versions are: -->
<!--     NDM/XML-50x.0.W-1.8 White Book (09/2005) -->
<!--     ODM 502.0-B-1 Blue Book (09/2004) -->
<!--     ADM 504.0-W-2.5 White Book (09/2005) -->
<!--     TDM 503.0-W-1.18 White Book (09/2005) -->
<!-- -->
<!-- -->
<!-- ***** WHITE BOOK CHANGE LOG ***** -->
<!-- 09/30/2005 (Action item from Fall Meetings) -->
<!-- 1. New module, introduced as part of the upgrade to a -->
<!-- modularized schema. -->
<!-- 2. Added compatibility with ADM 2.5 White Book -->
<!--*****-->

<!--*****-->
<!-- Generic Header specification for all Navigation Data Messages -->
<!-- (ndmHeader) -->
<!--*****-->
<xsd:complexType name="ndmHeader">
    <xsd:sequence>
        <xsd:choice>
            <xsd:element name="CCSDS_AEM_VERS" type="versionType"
                fixed="0.2.5"/>
            <xsd:element name="CCSDS_APM_VERS" type="versionType"
                fixed="0.2.5"/>
            <xsd:element name="CCSDS_OEM_VERS" type="versionType"
                fixed="1.0"/>
            <xsd:element name="CCSDS_OPM_VERS" type="versionType"
                fixed="1.0"/>
            <xsd:element name="CCSDS_TDM_VERS" type="versionType"
                fixed="0.1.18"/>
        </xsd:choice>
        <xsd:element name="COMMENT" type="xsd:string"
            minOccurs="0" maxOccurs="unbounded"/>
            <xsd:element name="CREATION_DATE" type="epochType"/>
            <xsd:element name="ORIGINATOR" type="xsd:string"/>
    </xsd:sequence>
</xsd:complexType>

<!--*****-->
<!-- Simple Types and Complex Types shared in the various NDM messages -->

```

# DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```
<!--*****-->
<!--*****-->
<!-- NOTE: convoluted structure for "epochType" seems necessary in -->
<!-- order to convey the "yyyy-dddThh:mm:ss.d->dZ" structure. There -->
<!-- is no built-in type in the XML Schema language that describes this -->
<!-- structure. In the pattern, "\p{Nd}" represents a numeric digit. -->
<!--*****-->
<xsd:simpleType name="epochType">
  <xsd:restriction base="xsd:string">
    <xsd:pattern value="-?\d{4}\d*-(\d{2}-\d{2})|\d{3})T\d{2}:\d{2}:\d{2}(\.\d*)?(Z|[+|-]\d{2}:\d{2})?| [+|-]?\d*(\.\d*)?"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:complexType name="stateVectorType">
  <xsd:sequence>
    <xsd:element name="COMMENT" type="xsd:string"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="EPOCH" type="epochType"/>
    <xsd:element name="X" type="distanceType"/>
    <xsd:element name="Y" type="distanceType"/>
    <xsd:element name="Z" type="distanceType"/>
    <xsd:element name="X_DOT" type="speedType"/>
    <xsd:element name="Y_DOT" type="speedType"/>
    <xsd:element name="Z_DOT" type="speedType"/>
  </xsd:sequence>
</xsd:complexType>

<xsd:complexType name="distanceType">
  <xsd:simpleContent>
    <xsd:extension base="xsd:double">
      <xsd:attribute name="units" type="distance" use="optional"/>
    </xsd:extension>
  </xsd:simpleContent>
</xsd:complexType>

<xsd:simpleType name="distance">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="km"/>
    <xsd:enumeration value="KM"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:complexType name="speedType">
  <xsd:simpleContent>
    <xsd:extension base="xsd:double">
      <xsd:attribute name="units" type="speed" use="optional"/>
    </xsd:extension>
  </xsd:simpleContent>
</xsd:complexType>

<xsd:simpleType name="speed">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="km/s"/>
    <xsd:enumeration value="KM/S"/>
```

```
</xsd:restriction>
</xsd:simpleType>

<xsd:complexType name="massType">
  <xsd:simpleContent>
    <xsd:extension base="nonNegativeDouble">
      <xsd:attribute name="units" type="massUnits" use="optional"/>
    </xsd:extension>
  </xsd:simpleContent>
</xsd:complexType>

<xsd:complexType name="deltamassType">
  <xsd:simpleContent>
    <xsd:extension base="negativeDouble">
      <xsd:attribute name="units" type="massUnits" use="optional"/>
    </xsd:extension>
  </xsd:simpleContent>
</xsd:complexType>

<xsd:simpleType name="massUnits">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="kg"/>
    <xsd:enumeration value="KG"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:complexType name="areaType">
  <xsd:simpleContent>
    <xsd:extension base="nonNegativeDouble">
      <xsd:attribute name="units" type="areaUnits" use="optional"/>
    </xsd:extension>
  </xsd:simpleContent>
</xsd:complexType>

<xsd:simpleType name="areaUnits">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="m**2"/>
    <xsd:enumeration value="M**2"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:complexType name="durationType">
  <xsd:simpleContent>
    <xsd:extension base="nonNegativeDouble">
      <xsd:attribute name="units" type="timeUnits" use="optional"/>
    </xsd:extension>
  </xsd:simpleContent>
</xsd:complexType>

<xsd:simpleType name="timeUnits">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="s"/>
    <xsd:enumeration value="S"/>
  </xsd:restriction>
```

## DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```
</xsd:simpleType>

<xsd:complexType name="angleType">
  <xsd:simpleContent>
    <xsd:extension base="angleRange">
      <xsd:attribute name="units" type="angleUnits" use="optional"/>
    </xsd:extension>
  </xsd:simpleContent>
</xsd:complexType>

<xsd:simpleType name="angleRange">
  <xsd:restriction base="xsd:double">
    <xsd:minInclusive value="-180.0"/>
    <xsd:maxExclusive value="360.0"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="angleUnits">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="deg"/>
    <xsd:enumeration value="DEG"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:complexType name="angleRateType">
  <xsd:simpleContent>
    <xsd:extension base="xsd:double">
      <xsd:attribute name="units" type="angleRateUnits" use="optional"/>
    </xsd:extension>
  </xsd:simpleContent>
</xsd:complexType>

<xsd:simpleType name="angleRateUnits">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="deg/s"/>
    <xsd:enumeration value="DEG/S"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="versionType">
  <xsd:restriction base="xsd:string">
    <xsd:pattern
value="\p{Nd}(\p{Nd})?\.\p{Nd}(\p{Nd})?(.\p{Nd}(\p{Nd})?)?" />
  </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="negativeDouble">
  <xsd:restriction base="xsd:double">
    <xsd:maxExclusive value="0.0"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="nonNegativeDouble">
```

```
<xsd:restriction base="xsd:double">
    <xsd:minInclusive value="0.0"/>
</xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="positiveDouble">
    <xsd:restriction base="xsd:double">
        <xsd:minExclusive value="0.0"/>
    </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="percentType">
    <xsd:restriction base="xsd:double">
        <xsd:minInclusive value="0.0"/>
        <xsd:maxInclusive value="100.0"/>
    </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="quaternionComponentType">
    <xsd:restriction base="xsd:double">
        <xsd:minInclusive value="-1.0"/>
        <xsd:maxInclusive value="1.0"/>
    </xsd:restriction>
</xsd:simpleType>

<xsd:complexType name="quaternionRateType">
    <xsd:simpleContent>
        <xsd:extension base="xsd:double">
            <xsd:attribute name="units" type="quaternionRateUnits"
use="optional"/>
        </xsd:extension>
    </xsd:simpleContent>
</xsd:complexType>

<xsd:simpleType name="quaternionRateUnits">
    <xsd:restriction base="xsd:string">
        <xsd:enumeration value="s*-1"/>
        <xsd:enumeration value="S*-1"/>
        <xsd:enumeration value="1/s"/>
        <xsd:enumeration value="1/S"/>
    </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="rotseqType">
    <xsd:restriction base="xsd:string">
        <xsd:enumeration value="121"/>
        <xsd:enumeration value="123"/>
        <xsd:enumeration value="131"/>
        <xsd:enumeration value="132"/>
        <xsd:enumeration value="212"/>
        <xsd:enumeration value="213"/>
        <xsd:enumeration value="231"/>
        <xsd:enumeration value="232"/>
        <xsd:enumeration value="312"/>
        <xsd:enumeration value="313"/>
    </xsd:restriction>
</xsd:simpleType>
```

## DRAFT XML SPECIFICATION FOR NAVIGATION DATA MESSAGES

```
<xsd:enumeration value="321"/>
<xsd:enumeration value="323"/>
</xsd:restriction>
</xsd:simpleType>

</xsd:schema>
```

## ANNEX J

### NDM/XML EXAMPLES

#### (INFORMATIVE)

An assortment of instantiations of the NDM/XML Schema may be found on the CCSDS web page at:

<http://public.ccsds.org/sites/cwe/moims-nav/Public/Schemas/TestFiles/ndmxml-1.8.xml>

These test XML instantiations in conjunction with the NDM/XML schema in annex C will validate successfully when validation-checked using the XML validator available at <http://tools.decisionsoft.com/schemaValidate.html>. At the time of this publication the suggested URL is active. Users may need to find a current validation tool in the future.

## ANNEX K

### INFROMATIVE REFERENCES

#### (INFORMATIVE)

- [K1] *Navigation Data—Definitions and Conventions.* Report Concerning Space Data System Standards, CCSDS 500.0-G-1. Green Book. Issue 1. Washington, D.C.: CCSDS, June 2001.
- [K2] *Information Technology—8-Bit Single-Byte Coded Graphic Character Sets—Part 1: Latin Alphabet No. 1.* International Standard, ISO/IEC 8859-1:1998. Geneva: ISO, 1998.
- [K3] *Time Code Formats.* Recommendation for Space Data System Standards, CCSDS 301.0-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, January 2002.
- [K4] *XML in CCSDS.* PowerPoint presentation at CCSDS Spring 2004 Meetings, Montreal, Canada, <[http://www.ccsds.org/docu/dscgi/ds.py/Get/File-1705/CCSDS\\_Workshop\\_Montreal\\_2004.ppt](http://www.ccsds.org/docu/dscgi/ds.py/Get/File-1705/CCSDS_Workshop_Montreal_2004.ppt)>

NOTE – Normative references appear in 1.5.